

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 7571 (1974): Methods of tests for ceramic for telecommunication and allied purposes [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



IS : 7571 - 1974

(Reaffirmed 2005)

Indian Standard

METHODS OF TESTS FOR CERAMICS FOR TELECOMMUNICATION AND ALLIED PURPOSES

(First Reprint APRIL 1997)

UDC 621.315.612 : 621.39 : 620.16

© Copyright 1976

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 8

February 1976

Indian Standard

METHODS OF TESTS FOR CERAMICS FOR TELECOMMUNICATION AND ALLIED PURPOSES

Insulating Materials Sectional Committee, ETDC 18

Chairman

SHRI A. S. LAKSHMANAN

Representing

Senapathy Whiteley (Pvt) Ltd, Bangalore

Members

SHRI B. A. GOVINDARAJ (*Alternate to*
Shri A. S. Lakshmanan)

SHRI R. S. ARORA

Directorate General of Supplies & Disposals, New
Delhi

SHRI G. R. BHATIA (*Alternate*)

DR A. S. BHADURI

National Test House, Calcutta

SHRI S. K. MUKHERJEE (*Alternate*)

SHRI C. E. BHASKAR RAO

Bharat Bijlee Ltd, Bombay

SHRI S. G. DESHMUKH (*Alternate*)

SHRI R. N. DHAR

National Physical Laboratory (CSIR), New Delhi
Central Water & Power Commission (Power
Wing), New Delhi

DIRECTOR, CENTRAL POWER RE-
SEARCH INSTITUTE

DEPUTY DIRECTOR, CENTRAL

POWER RESEARCH INSTITUTE (*Alternate*)

SHRI K. DORAISWAMY

Dr Beck and Co (India) Ltd, Poona

SHRI S. B. BAPAT (*Alternate*)

SHRI V. D. ERANDE

Hindustan Brown Boveri Ltd, Bombay

SHRI A. S. BENDRE (*Alternate*)

SHRI S. N. GANDHI

Permal Wallace Ltd, Bhopal

SHRI K. T. SHAMASUNDAR (*Alternate*)

SHRI P. N. HIRIYANNAIAH

Kirloskar Electric Co Ltd, Bangalore

DR B. N. JAYARAM (*Alternate*)

SHRI J. R. MAHAJAN

Indian Electrical Manufacturers' Association, Bombay

SHRI G. H. RODRICKS (*Alternate*)

SHRI M. K. MAJUMDAR

Bharat Heavy Electricals Ltd, Bhopal

SHRI M. V. DALAL (*Alternate*)

SHRI S. K. MANI

Directorate of Standardization (DGI) (Ministry of
Defence), New Delhi

SHRI D. S. DHANOTA (*Alternate*)

PROF R. S. NAGARAJA RAU

Indian Institute of Science, Bangalore

SHRI P. L. PRADHAN

Jyoti Ltd, Baroda

SHRI D. K. KULKARNI (*Alternate*)

(Continued on page 2)

© Copyright 1976

BUREAU OF INDIAN STANDARDS

This publication is protected under the *Indian Copyright Act* (XIV of 1957) and reproduction in whole or in part by any means except with written permission of the publisher shall be deemed to be an infringement of copyright under the said Act.

(Continued from page 1)

<i>Members</i>	<i>Representing</i>
SHRI S. R. RAMACHANDRAN	Power Cables Pvt Ltd, Bombay
DR G. M. PATEL (<i>Alternate</i>)	
SHRI S. P. RANADE	Crompton Greaves Ltd, Bombay
SHRI D. H. PAI (<i>Alternate</i>)	
SHRI R. SEN	Hindustan Cables Ltd, Rupnarampur
SHRI KALYAN GHOSH (<i>Alternate</i>)	
SHRI S. SEN GUPTA	Formica India Ltd, Poona
SHRI N. RAMCHANDRAN (<i>Alternate</i>)	
SHRI S. S. SHARMA	Jhaveri Thanawala Corporation, Bombay
SHRI K. T. THANAWALA (<i>Alternate</i>)	
SHRI A. N. SRIVATHSA	NGEF Ltd, Bangalore
SHRI ASWATHNARAYANANA (<i>Alternate</i>)	
DR J. VAID	Philips India Ltd, Bombay
SHRI N. SRINIVASAN, Director (Elec tech)	Director General, ISI (<i>Ex-officio Member</i>)

Secretaries

SHRI S. K. GAMBHIR
Assistant Director (Elec tech), ISI

SHRI HARCHARAN SINGH
Assistant Director (Elec tech), ISI

Indian Standard

METHODS OF TESTS FOR CERAMICS FOR TELECOMMUNICATION AND ALLIED PURPOSES

FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 28 November 1974, after the draft finalized by the Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 'Indian Standard specification for ceramics for telecommunication and allied purposes' (IS : 6659-1971) prescribes the performance requirements of ceramics for telecommunication and allied purposes. This standard has been prepared to cover test procedures to verify the performance requirements of ceramics.

0.3 While preparing this standard, considerable assistance has been derived from the following :

VDE 0305 Part 4/10.55 Determination of the relative dielectric constant and of the dielectric loss factor. Verband Deutscher Elektrotechniker (VDE).

VDE 0335/7.56 Testing of ceramic insulating materials. Verband Deutscher Elektrotechniker (VDE).

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard prescribes the methods of tests for the performance requirements of ceramics such as, steatite and ceramic oxide for telecommunication and allied purposes.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 6659-1971* shall apply.

3. MECHANICAL TESTS

3.1 Water Absorptivity

3.1.1 The water absorptivity is the quantity of water absorbed up to saturation by a test piece in percentage of its dry mass.

3.1.2 For determining the water absorptivity (*WA*), a Rupp desiccator is used (*see* Fig. 1).

3.1.2.1 The Rupp desiccator consists of a shallow lower basin *a* and a bell jar *b* provided with ground edge which has a wide neck *c*. A rubber stopper with two holes *d* is inserted in the neck; through one hole of the stopper is introduced a glass tube with a 3-way cock *e*. At the lower end of this cock an obtuse angle bent glass tube *g* is attached through a short rubber tube *f*. The end of the glass tube *g* penetrates into a glass basin *h* with vertical walls (crystallizing basin). The basin has a diameter of about 15 cm and a height of about 8 cm and serves as a receptacle of the test pieces.

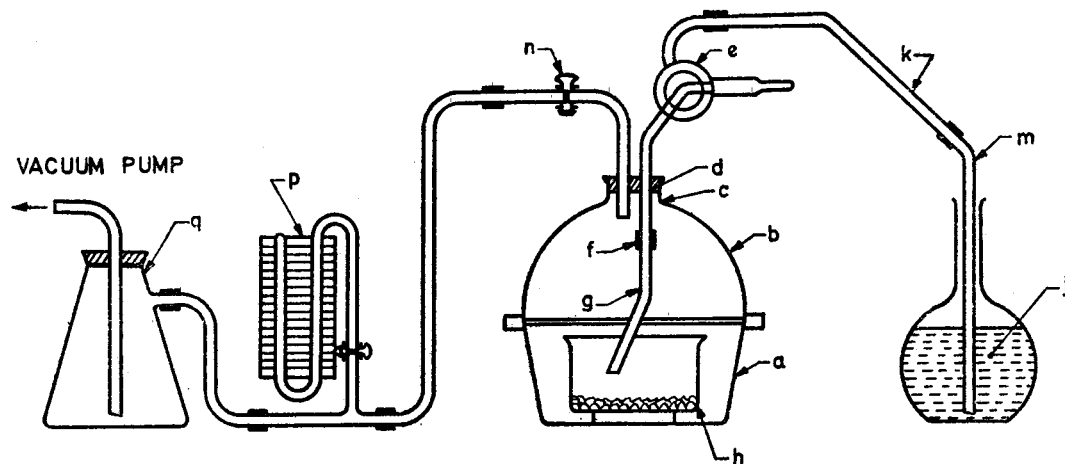
3.1.2.2 In a 1-l upright flask, distilled water is boiled for 5 minutes for removing all dissolved air. In the upright flask *j* filled with the air-free water, a glass tube *m* is introduced and this glass tube is connected through a rubber tube *k* to the second connection of the 3-way cock. The third connection of the 3-way cock is used to bring, by slight suction, the airless water into the glass tube, in the rubber tube and in the second connection of the 3-way cock. In the other hole of the rubber stopper *d*, a glass tube bent at right angles with the cock *n* is introduced. The vacuum pump (for example, a securely working water-jet vacuum pump) is connected to the glass tube with cock through a manometer *p* and a safety flask *q* with rubber tubes.

3.1.3 The test pieces are constituted by broken pieces of the insulator of mass about 50 g or broken pieces of the same mass from the finished electrical appliances. Any metal part or cement should be carefully removed from the test piece before the test. Preferably do not use glazed parts.

3.1.4 The test pieces should be dried for 3 hours at 150°C. After the test pieces have cooled down in a desiccator filled with a drying agent, their dry mass is determined correct to 0.01 g.

3.1.4.1 The test pieces are laid in the glass dish of the desiccator. Using a vacuum pump, maintain in the desiccator and in the tubes a pressure of 650 N/m² or less for 15 minutes. Then introduce the prepared distilled water (boiled to air-free state and cooled) in a thin stream into the glass basin till the pieces are completely covered with water, all the while maintaining the

*Specification for ceramics for telecommunication and allied purposes.



a = basin
b = bell jar with ground edge
c = neck
d = rubber stopper with two holes
e = 3-way cock
f = rubber tube
g = bent glass tube

h = glass basin
j = upright flask filled with airless water
k = long rubber tube
m = long glass tube bent at the top
n = cock
p = manometer
q = safety flask

FIG. 1 APPARATUS FOR DETERMINING THE WATER ABSORPTIVITY (WA)

pressure of 650 N/m² or less. Now turn off the suction action by operating the cock *n*. Then allow outside air to stream into the desiccator through the third connection of the 3-way cock. The test pieces shall remain at least 12 hours inside water and under normal atmospheric pressure.

3.1.4.2 After this period, remove the pieces one by one from the water and wipe off the surface water with a cotton cloth. The cloth should have been previously dipped in water and wrung so that it is slightly moist. Depressions and hollows should be wiped with a slightly moist brush.

3.1.4.3 Then determine the mass of the water-saturated test pieces correct to 0.01 g. The measurements shall be made between 5 and 10 minutes from the time of removal from water. From this value, up to 0.3 percent may be subtracted for pieces with rough surface in order to take into account the water adhering to the surface.

3.1.5 The water absorptivity is then given by the following formula :

$$WA = \frac{(G_w - G)}{G} \times 100$$

where

WA = water absorption in percentage,

G = dry mass of the test pieces in g, and

G_w = mass of the water-saturated pieces in g.

3.1.6 The water absorptivity should be determined on at least three test pieces to 0.1 percent.

3.2 Volumetric Mass (Density)

3.2.1 The volumetric mass γ of a material is the quotient of its mass in kilograms divided by its volume (including pore volume) in m³.

3.2.2 The test pieces are constituted by regularly shaped bodies, for example, cubes or cylinders of at least 25 ml volume. The dimensions are measured correct to 0.1 mm with vernier callipers and the mass is determined correct to 0.01 g.

3.2.3 The volumetric mass is determined according to the following formula :

$$\gamma = \frac{G}{V} \times 10^{-3}$$

where

γ = volumetric mass in kg/m³,

G = dry mass of the test piece in g, and

V = volume of the test piece in m³.

3.2.4 If the ceramic material is compact and of irregular shape, the volumetric mass may also be determined according to the buoyancy method.

3.2.4.1 In the case of irregular shaped, non-compact fired ceramic materials, a thin layer of petroleum jelly shall be applied to the surface and the formula for the calculation of volumetric mass (density) shall be as follows :

$$\gamma = \frac{M_1}{V} \text{ g/cm}^3$$

where

V = volume of test piece [$M_2 - (M_3 - M_4)$] in cm^3 ;

M_1 = mass of the test specimen in g;

M_2 = mass of the test specimen covered with petroleum jelly in g;

M_3 = mass of the test specimen in g, covered with petroleum jelly and immersed in water along with the mass of the suspension wire; and

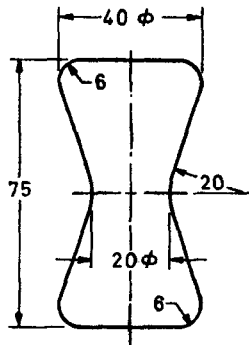
M_4 = mass of the suspension wire in g.

3.2.5 The volumetric mass should be determined for at least 3 test specimens (which have been carefully dried before hand at 110°C) correct to 0.01 g/cm^3 .

3.3 Tensile Strength

3.3.1 The tensile strength $\sigma_z B$ is the tensile load referred to the unit of the smallest cross section at which the test piece breaks, the load having been increased gradually.

3.3.2 The test piece shall be shaped as shown in Fig. 2 and its length shall be 75 mm. It shall have flattened ends and at the central contracted region the diameter shall be 20 mm. The largest diameter at the ends shall be 40 mm. The piece should be extruded and subsequently turned (*see* Fig. 2).

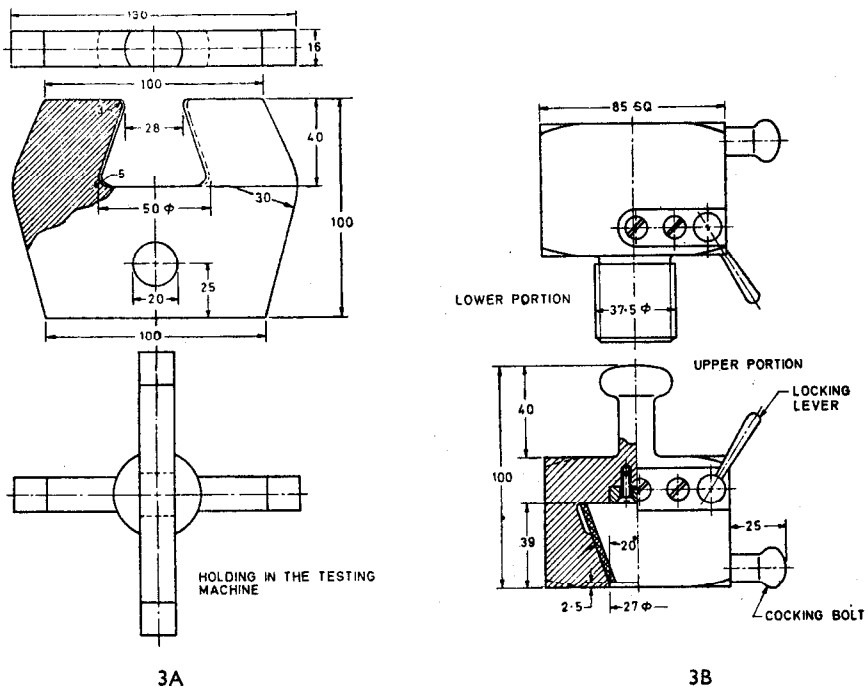


All dimensions in millimetres.

FIG. 2 TENSILE TEST PIECE

3.3.3 The test pieces are held in the cross clamps (*see* Fig. 3A) or in the gripping head (*see* Fig. 3B) of the tensile testing machine with some soft

material in between and slowly loaded till breakage. The load shall be increased at the rate of 300 to 400 N/s.



3A

3B

All dimensions in millimetres.

FIG. 3 CLAMPING DEVICE FOR TENSILE TESTING

3.3.4 The tensile strength is determined according to the following formula :

$$\sigma_z B = \frac{F}{A}$$

where

$\sigma_z B$ = tensile strength in N/m²,

F = breaking load in N, and

A = smallest cross section in m².

3.3.5 The tensile strength should be determined on at least five test specimens, the values are rounded off to the nearest MN/m².

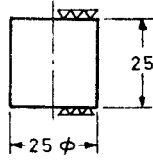
3.3.6 If the material cannot be extruded, the tensile test is omitted.

3.4 Compression Strength

3.4.1 The compression strength $\sigma_d B$ is the compression load referred to

the unit cross section at which the test piece breaks the load having been increased uniformly, that is, without jerks.

3.4.2 The test piece is a cylinder of 25 mm diameter and 25 mm height whose ends are ground parallel (*see* Fig. 4). They shall be produced according to the relevant methods in practice.



All dimensions in millimetres.

FIG. 4 TEST PIECE FOR DETERMINING THE COMPRESSION STRENGTH

3.4.3 The test pieces are held with an intermediate layer of writing paper in the testing machine and loaded until it breaks completely, the load being increased uniformly at the rate of between 3 000 and 4 000 N/s.

3.4.4 The compression strength is determined according to the following formula:

$$\sigma_{dB} = \frac{F}{A}$$

where

σ_{dB} = compression strength in N/m²,

F = breaking load in N, and

A = cross section of the test piece in m².

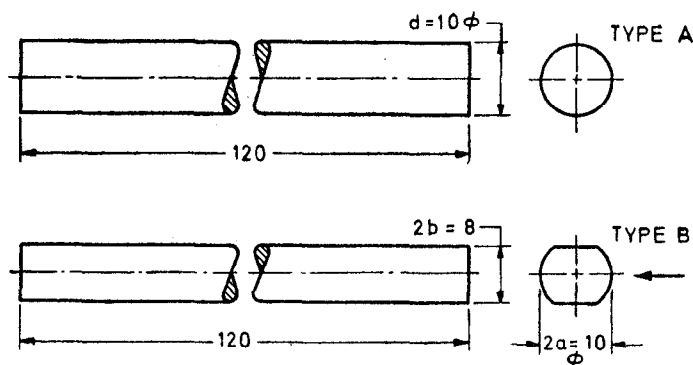
3.4.5 The compression strength should be determined on at least 5 test pieces. The values are rounded off to the nearest 10 MN/m² and the method of production of the test piece is indicated.

3.5 Bending Strength

3.5.1 The bending strength σ_{bB} is the bending load referred to the unit cross section at which the test piece breaks, the load having been increased uniformly.

3.5.2 The test pieces used are bars as shown in Fig. 5. Type A is for extruded or cast test pieces, while type B is used preferably for pressed test pieces.

3.5.3 The pressing direction when forming the test piece shall be according to type B and the loading direction during the test shall be according to Fig. 5.



All dimensions in millimetres.

Type A With Round Cross Section

Type B With Flattened (Oval) Cross Section

(The Arrow indicates the Direction of Pressing and Loading)

FIG. 5 TEST PIECE FOR DETERMINING THE BENDING AND IMPACT BENDING STRENGTH

3.5.4 The supports in the bending testing machine shall be two steel rollers of 10 mm diameter spaced at 100 mm between their axes (supporting width L). The load shall be applied over a third steel cylinder of 10 mm diameter on the middle of the test piece and increased till the latter breaks, the rate of increase being about 50 N/s.

3.5.5 The bending strength is determined according to the following formula :

$$\sigma_b B = \frac{FL}{4W}$$

where

$\sigma_b B$ = bending strength in N/m²,

F = breaking load in N,

L = supporting width in m, and

W = moment of resistance in m³.

3.5.6 The resistance moment for type A test piece is

$$W = \frac{\pi}{32} d^3 \approx 0.1 d^3$$

3.5.7 For type B test pieces, the moment of resistance may be calculated by assuming roughly that the test piece has an elliptical cross section with the semi-axes a and b (see Fig. 5). The moment of resistance is :

$$W = \frac{\pi}{4} a^2 b \approx 0.8 a^2 b$$

3.5.8 The bending strength should be determined on at least 5 test pieces. The values shall be rounded off to the nearest MN/m². The test report should contain an indication of the method of production.

3.6 Impact Bending Strength

3.6.1 The impact bending strength a_n is the impact work referred to the unit cross section at which the test piece subjected to impact bending stress breaks.

3.6.2 The test pieces are bars according to 3.5.2.

3.6.3 The direction of pressing when forming the test piece shall be according to type B and the direction of impact in the testing shall be according to Fig. 5.

3.6.4 The impact bending strength is calculated according to the following formula :

$$a_n = \frac{A}{F}$$

where

a_n = impact bending strength in kJ/m²,

A = impact work of the pendulum hammer in kJ, and

F = cross section of the bar (not the break face area) in m².

3.6.5 The impact bending strength should be determined on at least five test pieces and expressed to the nearest 0.1 kJ/m².

3.7 Elasticity Modulus

3.7.1 The elasticity modulus (E) is the mechanical stress referred to unit area, N/m², at which the original length of the body would have doubled.

3.7.1.1 The reciprocal of the elasticity modulus is termed the strain coefficient or elongation coefficient (m²/N).

3.7.2 The test piece is a round bar of 16 mm diameter and 500 mm length. The test piece is formed by extrusion.

3.7.3 The test piece is supported on two knife edges separated by 40 cm ($r = 1$ mm). The bar is then loaded in its centre without any jerks, the pressure being transmitted by a steel blade ($r = 10$ mm).

3.7.4 In this determination, the bending of the test bar is first calculated. From the bending, the elasticity modulus is calculated according to the following formula :

$$E = \frac{l^3 \cdot (P - P_0)}{48 \cdot \bar{f} \cdot f}$$

where

E = elasticity modulus in N/m²,

l = distance between the supports in m,

$P - P_0$ = load reduced by the initial load in N,

$\bar{J}$ = moment of inertia in m^4 , and

f = bending of the bar in the middle in m.

3.7.5 Test shall be carried out on three test pieces all of which shall pass the test.

3.8 Shear Modulus (Modulus of Rigidity)

3.8.1 The elastic shear is the ratio of the length by which a surface shifts with respect to another parallel surface under the action of a shear stress (N/m^2) to the distance between the two surfaces.

3.8.1.1 The shear coefficient (m^2/N) is the ratio of the elastic shear to the acting shear stress.

3.8.1.2 The reciprocal of the shear coefficient is termed as shear modulus, N/m^2 .

3.8.2 The shear modulus is calculated from the twist angle in the test of the torsion strength.

3.8.3 The test pieces are constituted by round bars of 140 mm length and 16 mm diameter. Their ends to about 25 mm length are square shaped for being clamped in the testing machine (see Fig. 6). The opposite surfaces of the square should be parallel and symmetrical with respect to the middle axis. For measuring the twist angle, two small mirrors are used. They are fixed on the test bar at a distance of 65 mm which serves as the measuring distance and their turning in opposite directions is measured with collimators and scales. Then,

- a), if a is the difference of scale readings on the circular scale and A is the distance from the middle of the bar to the scale, the twist angle α_e in radians is:

$$\alpha_e = \frac{a}{2A}$$

- b) From the twist angle α_e , the shear modulus G is calculated as follows:

$$G = \frac{M_t \cdot l \cdot 32}{\alpha_e \cdot d^4 \cdot \pi} \text{ N/m}^2$$

where

M_t = moment of torsion in Nm,

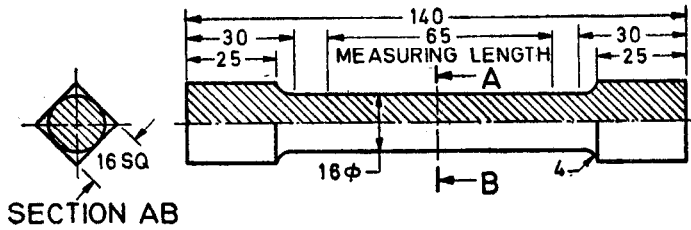
l = length of the test bar between the mirror marks in m,

α_e/l = twist angle referred to unit length, and

d = diameter of the test bar in m.

3.8.4 The method adopted for making the test bar should be indicated every time.

3.8.5 Test shall be carried out on three test pieces all of which shall pass the test.



All dimensions in millimetres.

FIG. 6 TEST BAR FOR MEASURING THE TWIST ANGLE

3.9 Mohs Hardness

3.9.1 The Mohs hardness (MH) indicates the relative scratch hardness through minerals. Appendix A gives the hardness number and the mineral according to the modified Mohs scale.

3.9.2 The hardness should be determined by comparison with the minerals of the Mohs hardness scale and expressed by the values of this scale.

3.9.3 The materials to be tested and the minerals of the hardness scale shall be in the form of sharp edged pieces.

3.9.4 If the material to be tested does not scratch one of the minerals of the scale but is also not scratched by the latter, both have the same hardness. If the material scratches a mineral of the scale and is scratched by the next harder mineral of the scale, its hardness lies between those of the two minerals.

3.9.5 Three test pieces shall be tested and all of them shall pass the test.

4. THERMAL TESTS

4.1 Coefficient of Linear Expansion

4.1.1 The coefficient of linear expansion α_t is the change of the unit length of a solid substance when the temperature increases by 1°C , referred to the length at 20°C .

4.1.2 It should be determined as the heat expansion coefficient for the temperature range from 20 to 100°C and, if necessary, from 20 to 800°C in $\text{m}/\text{m}^\circ\text{C}$.

4.1.3 For determining the coefficient of linear expansion, commercially available instruments may be used. The following procedure, for example, is suitable.

4.1.3.1 A bar is cut out of the material to form the test piece and is ground to the required dimensions : length 50 mm and diameter about 4 mm .

4.1.3.2 The test piece is introduced in a quartz glass tube (closed on

one side) of an electric heater and pressed against the inside bottom of the tube with a quartz glass rod which is adjacent to the test piece. The expansion of the test piece is transmitted through the quartz rod on to a dial gauge which has a scale division of 1/1 000 mm. The apparatus is arranged horizontally. Near the test piece there is a thermoclement to measure the temperature.

4.1.3.3 The increase of temperature during the entire measurement is 25°C in 5 minutes. The elongation is read off in microns with every temperature increase of 25°C and for each temperature read, the elongation is expressed in percentage of the initial length at room temperature.

4.1.3.4 The expansion of the quartz glass parts is taken into account by introducing a correction factor. This correction is either indicated on the apparatus or else determined by a test with the measuring body of known heat expansion.

4.1.3.5 By the addition of the percentage quartz glass correction to the percentage elongation, the actual percentage increase a of the test piece may be obtained. From this, coefficient of heat expansion is determined as follows:

$$\alpha_t = \frac{a}{100 t}$$

where

α_t = mean linear heat expansion coefficient in 10^{-6} m/m°C for the temperature range from the initial temperature to the measuring temperature, and

t = difference between the initial temperature and the measuring temperature.

4.1.4 The form of the test piece is suitably chosen according to the testing apparatus used.

4.1.5 Test shall be carried out on three test pieces all of which shall pass the test.

4.2 Specific Heat

4.2.1 The specific heat c of a material is that quantity of heat in kcal which is necessary to increase the temperature of 1 kg of this material by 1°C.

4.2.2 It is determined as the mean specific heat c_m for the temperature range from 20 to 100°C and, if necessary, from 20 to 800°C in J/kg°C.

4.2.3 For determining the specific heat, commercial appliances are used.

4.2.4 The shape of the test piece is chosen suitably according to the testing apparatus used.

4.2.5 Test shall be carried out on three test pieces all of which shall pass the test.

4.3 Thermal Conductivity

4.3.1 The thermal conductivity indicates by a numerical value the number of degrees by which the mean temperature of a cube of 1 m side increases when the temperature drop of two opposite sides differs by 1°C/m.

4.3.2 It is determined as a mean thermal conductivity a_m in m²/h for the region of temperature from 20 to 100°C.

4.3.2.1 A ceramic plate at 20°C is heated on a liquid metal layer at a known temperature. Using a stop-watch, measure the time taken for the non-heated side to attain a certain temperature.

4.3.3 The thermal conductivity should be determined on at least 3 test pieces to an accuracy of 1/10 000 m²/h.

4.4 Heat Conductivity

4.4.1 The heat conductivity λ indicates the number of kcal passing steadily through a cross section of 1 m² of a 1 m thick slab in one hour when the temperatures on the opposite sides of the slab are at a difference of 1°C.

4.4.2 The heat conductivity should be determined as the mean heat conductivity between 20 and 100°C and, if necessary, for other ranges like 100 to 300°C, 300 to 600°C and 600 to 800°C.

4.4.2.1 For determining the mean heat conductivity between 20 and 100°C, commercial apparatus shall be used.

4.4.3 The shape of the test piece is chosen suitably according to the apparatus used.

4.4.3.1 The arrangement may, for example, consist of 7 test pieces placed one over the other, the heat flow through the wooden cylinder heated from inside being measured perpendicularly to the axis of the cylinder.

4.4.4 The heat conductivity up to 100°C may also be calculated from the thermal conductivity according to 4.3, the specific heat according to 4.2 and the volumetric mass according to 3.2.

NOTE — This calculation is particularly suitable for rapid routine investigation but cannot replace the direct determination of the heat conductivity.

4.4.5 The heat conductivity is calculated according to the following formula:

$$\lambda = 1\,000\, a\, c\, \gamma$$

where

λ = heat conductivity in W/m°C,
 a = thermal conductivity in m²/h,
 c = specific heat in J/kg°C, and
 γ = volumetric mass in kg/m³.

4.4.5.1 In this method of calculation, the specific heat should be inserted as mean value c_m according to 4.2 and the thermal conductivity as

mean value α_m according to 4.3 between 20 and 100°C. For the heat conductivity, a mean value λ_m between 20 and 100°C may also be obtained.

4.5 Refractoriness, Seger Cone Drop Point

4.5.1 The refractory property is determined as the cone melting point in comparison to small seger cones. Small seger cones are about 2.5 cm high.

4.5.2 The test pieces shall have the same shape and size as the small seger cone.

4.5.3 The test pieces are heated along with the seger cones in an electric coal grit-resistance furnace until complete collapsing or bending of the test piece takes place, in the latter case the test piece lightly touches its base support.

4.5.3.1 The seger cone should be so placed that the shortest edge is vertical (see Fig. 7).

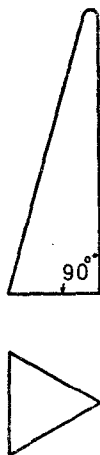


FIG. 7 SEGER CONE

4.5.3.2 For a correct assessment of the refractory property several determinations have to be affected. One of them should be with the next seger cone and two more with the seger cones that are just lower and just higher respectively to the test piece. These two determinations are considered completed if the next higher or next lower seger cone has gone down.

4.5.3.3 After the test, it shall be evident from the melted specimen that the heating has been uniform over the entire height of the specimen. There should not be single-side heating, nor an advance of the tip or of the base. Such wrong melted specimens should be rejected.

4.5.3.4 Above the seger cone 26 (code number 158 according to a melting point of 1 580°), the furnace should be heated such that the increase of temperature from cone to cone takes place in at least 5 and at the most 10 minutes.

4.5.4 The refractory property corresponds to the seger cone whose conditions corresponds to that of the test piece or the refractory property of the test piece between those of two consecutive seger cones.

4.5.5 The refractory property is designated by the number of the corresponding seger cone, for example, 33 (code number 173 corresponding to a melting point of 1 730°), or the numbers of two successive seger cones may be given, for example, 33/34 (code number 173/175 corresponding to a melting point of 1 730°/1 750°), when refractory property of the test piece lies between two seger cones. No other designations shall be allowed.

4.5.6 The test method is applicable for determinations up to seger cone 42.

4.5.7 Test shall be carried out on three test pieces all of which shall pass the test.

5. CHEMICAL TESTS

5.1 Resistance to Corrosion

5.1.1 Resistance to corrosion is the resistance to chemical attack.

NOTE — Ceramic materials are generally resistant to atmospheric corrosion even in the presence of salt, acid and alkali containing gases, water vapour and rain; the only exception being hydrofluoric acid.

5.1.2 *Test Procedure for Testing the Corrosion Resistance of Ceramic Materials*

5.1.2.1 The total surface of each specimen is determined correct to 2 percent. The test specimen and comparison specimen are thoroughly cleaned by hand, brush or clot cloth and water at room temperature. No chemical cleaning agent should be used. Then they are both rinsed with distilled water and finally with ethanol. They are then dried together in the hot chamber for 45 minutes at 150°C, then placed for 45 minutes in a desiccator to cool down. The desiccator should be near the balance so that immediately after cooling, the mass of the two specimens may be determined. The difference between their masses ΔG_1 is determined correct to 0.1 mg.

5.1.2.2 The next day, 500 to 600 ml of the hydrochloric acid (20.4 percent m/m) is heated in the beaker.

5.1.2.3 The test piece is suspended in the acid with platinum wire so that it is covered on all sides by the boiling acid.

5.1.2.4 After 6 hours the specimen is removed from the acid and thoroughly rinsed with distilled water. The comparison piece (not treated with acid) is similarly rinsed.

5.1.2.5 The two specimens are then dried at 150°C as described

in 5.1.2.1, cooled and their masses determined. The mass difference ΔG_2 between the specimens is determined correct to 0.1 mg.

NOTE — It is very important to observe this condition both times.

5.1.2.6 The determination is effected in the same way with a second specimen.

5.1.2.7 The difference in the two masses divided by the area of the surface of the specimen $\frac{\Delta G_1 - \Delta G_2}{A}$ gives the mass loss per unit area in mg/dm². If the results deviate by more than 10 percent from their average, then the test is repeated second time.

5.1.2.8 The average of the mass loss per unit surface is divided by 2. This value then indicates the acid class to which the specimen belongs.

5.1.3 When giving the test results, indicate whether the piece used for the test was glazed or unglazed.

5.1.4 Test shall be carried out on three specimens all of which shall pass the test.

6. ELECTRICAL TESTS

6.1 Dielectric (Puncture) Strength

6.1.1 The electric puncture voltage (U_d) is the effective value of sinusoidal voltage at which the puncture takes place.

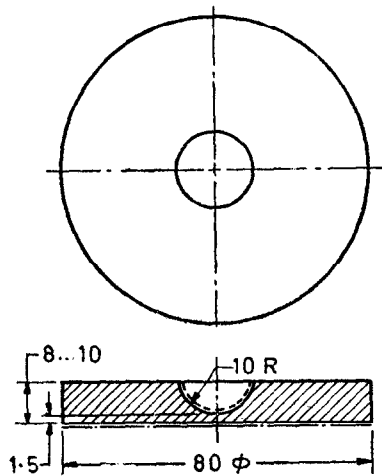
6.1.2 The electric puncture strength (dielectric strength) (E_d) is the quotient of the puncture voltage (U_d) and the minimum thickness (a) of the test piece measured between the electrodes. A uniform field strength at the place of measurement is assumed.

6.1.2.1 The dielectric strength is not any specific property of the material. It may be dependent on the thickness of the test piece, the voltage and the time of application of the voltage.

6.1.3 The measurement is carried out at $27 \pm 5^\circ\text{C}$. To avoid pre-discharge, the test pieces are tested under oil. The measurement is carried out with alternating voltage at 50 Hz. The peak factor should be between 1.34 and 1.48 (that is, $\sqrt{2} \pm 5$ percent). One of the two measuring electrodes should preferably be earthed.

6.1.4 The test piece is an unglazed flat plate of 80 mm diameter and 8 to 10 mm thickness with a cup shaped depression on one side (see Fig. 8). This depression should be made in the dried body before it is burnt. The diameter of the depression shall be 20 mm, the thinnest portion of the plate between the lowest point of the cup and the opposite plane surface shall be $1.5 \text{ mm} \pm 10$ percent. To obtain this dimension it may be necessary to grind the test piece on the flat side after being burnt. The depression and the opposite surface should be metallized in the burning process.

6.1.4.1 The test piece may also be in the form of tubes or plates up to



All dimensions in millimetres.

FIG. 8 TEST PIECE FOR DETERMINING THE DIELECTRIC STRENGTH

3 mm thickness if the material is not suitable for making larger plates (80 mm diameter).

6.1.5 The voltage is increased quickly to about half the expected puncture voltage, then at the rate of 0.5 to 1 kV every second until puncture.

6.1.6 The minimum thickness (a) taken as basis for the dielectric strength should be determined immediately before or after the measurement of the puncture voltage at the thinnest portion of the test piece (without considering the path of the puncture) preferably to an accuracy of 2 percent.

6.1.6.1 With the help of Fig. 9, the factor β for calculating the dielectric strength may be obtained (for the test piece shown in Fig. 8) from the measured smallest thickness.

$$E_d = U_d \cdot \beta \text{ kV/cm}$$

The following points have been plotted in Fig. 9 :

a mm	β
1.0	10.68
1.5	7.35
2.0	5.69
3.0	4.03
4.0	3.21
5.0	2.72

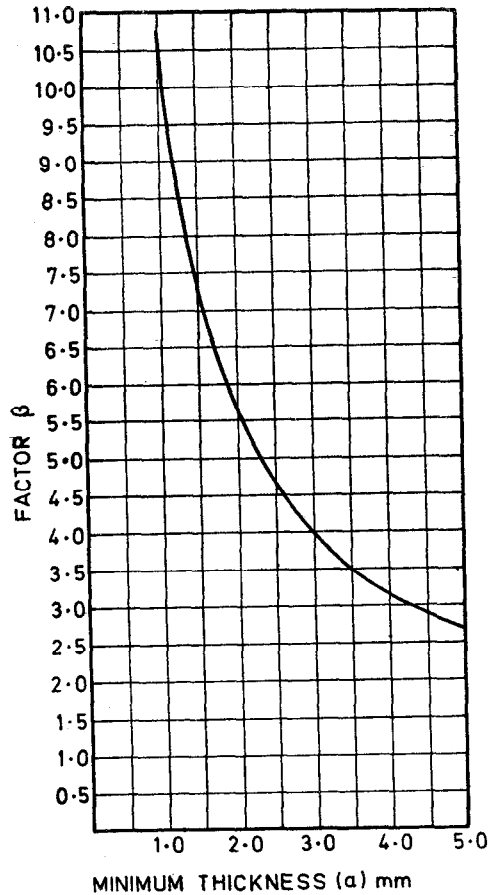


FIG. 9 CONVERSION FACTOR β IN THE MEASUREMENT OF THE PUNCTURE VOLTAGE OF TEST PIECES ACCORDING TO FIG. 8

6.1.7 The dielectric strength should be determined on at least 5 test pieces. The values shall be rounded off to the nearest kV/cm. The method of production should also be indicated. The test shall be carried out only on compact materials.

6.2 Dielectric Constant and Dissipation Factor

6.2.1 General

6.2.1.1 The relative dielectric constant (ϵ_r) of an insulating material

is the quotient of the capacitance of a condenser at which the space between the electrodes is completely occupied by the insulator (C_x) and the capacitance (C_0) of the same electrode arrangement in the air.

$$\epsilon_r = \frac{C_x}{C_0}$$

6.2.1.2 The dielectric loss tangent or dissipation factor ($\tan \delta$) of a material is the tangent of the shift angle by which the phase shift between the current and voltage in the capacitor deviates from $\pi/2$ when the dielectric of the capacitor is exclusively made up of the insulator.

6.2.1.3 The loss coefficient is the product of dielectric constant and dielectric loss tangent (or dissipation factor).

6.2.2 Apparatus

6.2.2.1 The following test apparatuses are required:

- a) An alternating voltage source with the frequency necessary for the measurement.
- b) A measuring arrangement permitting to express capacitance of the amount C_x to an accuracy of at least $(0.01 C_x + 1 \text{ pF})$ and the dielectric loss tangent of the amount Z to an accuracy of at least $(0.05 Z + 0.1 \times 10^{-3})$.
- c) An electrode arrangement in which the test piece is located between the electrodes in a, as far as possible, homogeneous or otherwise defined electric field.

Since the measuring equipments are of various types, the same form of the test piece will not be sufficient for the entire range of measurement from 15 to 10 000 Hz. Up to a frequency of 5 MHz plates are used. The rule for the size of the electrode area is that the capacitance C_x of the electrode arrangement shall be not less than 70 pF.

This condition is satisfied in most cases if the test piece is $120 \times 120 \text{ mm}$, or $150 \times 150 \text{ mm}$ for thicker test pieces and the electrode diameters specified in Table 1. If the test pieces are in the form of tubes, then also the surface of the test piece should be chosen large enough in order to use electrodes of such size that the capacitance of this arrangement does not come below 70 pF. One of the electrodes should be provided with a protective slit. The measurement area is that surface which is limited by the middle lines of the protective slit. The width g of the protective slit should be as small as possible, but in no case greater than 1 mm. The width of the protective ring should be equal to at least twice the thickness of the test piece (see Fig. 10).

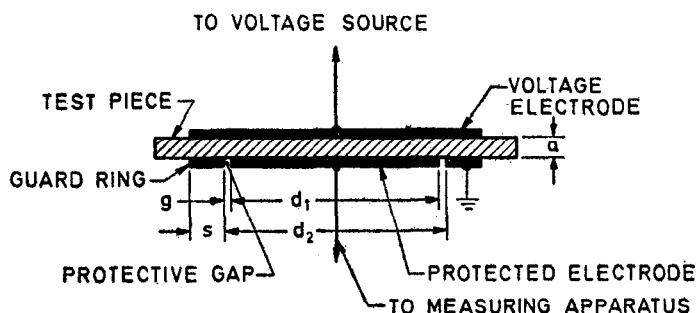


FIG. 10 CIRCULAR PLATE ELECTRODE WITH GUARD RING FOR TEST PIECES IN THE FORM OF PLATES

For measurements that are to be carried out in the frequency range of 1 to 100 MHz with plate electrodes, plates up to 5 mm thickness are suitable as test pieces. Their diameters should be as far as possible, equal to the diameter of the electrodes but may also be smaller. The capacitance of the test piece shall preferably be not less than 15 pF and not more than 80 pF. The electrodes shall be applied without protective ring.

For measurements in the frequency range from 60 to 10 000 MHz, cylindrical test pieces are used. For the range from 60 to 4 000 MHz, the test pieces are provided with a bore. In the region from 4 000 to 10 000 MHz in which hollow conductors are used, the bore of the cylindrical test piece is omitted. The length L of the test piece shall be so chosen that at least one-quarter of the wave lengths is in the test piece; it may also be an odd multiple of this value.

The electrodes are of metals which are burnt on to the surface of the insulator

- d) Instruments for measuring the thickness of the test piece accurate to 2 percent of the thickness ± 0.005 mm and the dimensions of the electrodes (for calculating the measuring area) correct to 1 percent.
- e) Chamber in which the air may be set to required conditions for the preliminary treatment and, if necessary, the testing of the test pieces. It should be possible to maintain the temperature accurate to 2°C and the relative humidity to 5 percent inside the chamber.
- f) Thermostat with a temperature setting range from $+20$ to $+150^{\circ}\text{C}$ to an accuracy of 2°C in the measurement of the dependancy on temperature of the relative dielectric constant and the dielectric loss tangent.

**TABLE 1 ELECTRODE DIAMETERS FOR TEST PIECES
THICKER THAN 120 mm**

[Clause 6.2.2.1(c)]

NOMINAL MEASURING SURFACE	d_1	g	MEASURING SURFACE DIAMETER $d_1 + g$	s
(1)	(2)	(3)	(4)	(5)
cm ²	mm	mm	mm	mm
5	24.2	1	25.2	10
20	49.5	1	50.5	10
80	99.9	1	100.9	10

6.2.3 Preliminary Treatment of the Test Piece

6.2.3.1 Preliminary treatment to achieve a particular initial condition of the test piece — The test pieces are generally dried for a period of 4 hours in a desiccator or a flat vessel with suitable drying agent.

6.2.3.2 Preliminary treatment to determine action of heat — The measurements are carried out after 24 hours at room temperature after storage in heat for specific time. The test pieces should be first dried and then brought to the measurement temperature in the hot or cold chamber in dry air.

6.2.3.3 Preliminary treatment for determining the action of moisture — The following treatments in increasing order of severity are included :

- Keeping in air at 65, 80 or 90 percent relative humidity and room temperature;
- Keeping in air of approximately 65 or 90 percent relative humidity and at higher temperature, $40 \pm 2^\circ\text{C}$ is recommended;
- Keeping in distilled water at room temperature (after removing the test piece from the water-bath, the water adhering to the surface is removed with non-fibrous filter paper); and
- Keeping in a flow of water vapour (after this any water on the surface is removed with non-fibrous filter paper).

6.2.4 Test Procedure

6.2.4.1 If a preliminary treatment of the test piece according to 6.2.3 is provided, the thickness of the test piece is first determined correct to 2 percent, the electrode is then applied and finally the preliminary treatments of the test piece are carried out. Within latest 2 minutes after the completion of the preliminary treatment, the measurements are carried out for determining the relative dielectric constant and the dielectric loss tangent.

6.2.4.2 Unless agreed otherwise, the measurements are carried out at $27 \pm 2^\circ\text{C}$ and 65 ± 5 percent relative humidity.

6.2.5 Assessment

6.2.5.1 Relative dielectric constant ϵ_r — The relative dielectric constant

ϵ_r is found out from the measured capacitance C_x and the capacitance of the electrode arrangement in air C_0 . If the capacitance C_x is measured without the protective ring it contains also the capacitance component C_0 which takes into account the boundary field and a capacitance component C_g which depends on the stray field. The corrected capacitance of C_x is obtained as :

$$C'_x = C_x - C_e - C_g \text{ pF}$$

For the individual electrode arrangements, the values C_e and C_g may be calculated according to Table 2 and, therefore, the limit measuring error, if they are neglected, may be estimated.

The capacitance of the electrode arrangement in air C_0 may be determined either by the measurement of the capacitance at the electrode arrangement in air or by calculation. If C_0 is measured, the same corrections as in Table 2 shall be applied as for the capacitance C_x so that the corrected capacitance of C_0 is obtained as :

$$C'_0 = C_0 - C_e - C_g$$

The formulae for the calculation of C_0 for the individual electrode arrangements shall also be taken from Table 2.

ϵ_r is given by :

$$\epsilon_r = \frac{C'_x}{C'_0}$$

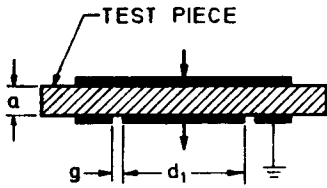
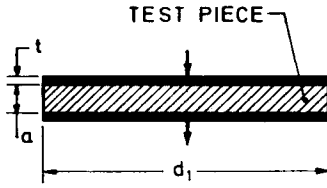
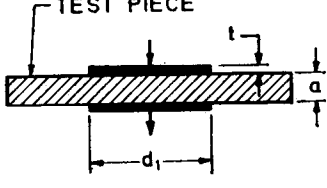
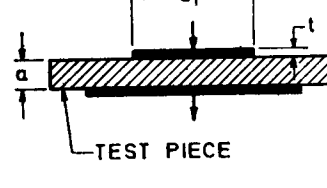
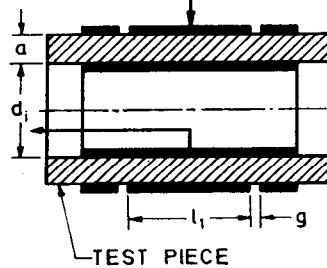
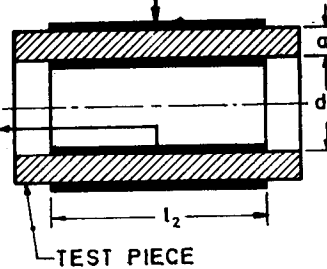
6.2.5.2 Dielectric loss tangent ($\tan \delta$) — The dielectric loss tangent ($\tan \delta$) is calculated from the values measured with the apparatus given below and is expressed in 10^{-3} .

a) *Description* — The circuit (see Fig. 11) consists of the following :

- 1) A guard ring capacitor for the test piece with the shielded capacitance C_{js} and the loss tangent $\tan \delta_1$. Here a series circuit of a loss-free capacitance with a resistance has been assumed as equivalent circuit.
- 2) A solid reference capacitor (capacitance C_2) which should be as loss-free as possible (air condenser).
- 3) A purely resistive (non-inductive) four decade resistance box R_3 [$10 \times 100 \Omega + 10 \times 10 \Omega + 10 \times 1 \Omega + 10 \times 0.1 \Omega + 0.1 \Omega$] (potentiometer wire)].
- 4) A solid non-inductive resistance R_4 for 50 Hz measurement, as a rule $318.3 \Omega = \frac{1000}{\pi} \Omega$ with parallelly connected three decade capacitance box C_4 [for example, $11 \times 0.1 \mu\text{F} + 11 \times 0.01 \mu\text{F} + 11 \times 0.001 \mu\text{F} + 0.001 \mu\text{F}$ (variable air condenser)].
- 5) A vibration galvanometer VG with electromagnetic or permanent magnetic tuning.
- 6) Shielding and protection against excess voltage.

TABLE 2 EVALUATION OF THE RESULTS OF MEASUREMENT
(Clause 6.2.5.1)

a) Determination of C_0 , C_e and ϵ_r

ELECTRODE ARRANGEMENT		CAPACITANCE OF THE ELECTRODE ARRANGEMENT IN AIR C_0 pF (2)	CAPACITANCE COMPONENT OF THE PERIPHERAL FIELD C_e pF (3)	RELATIVE DIELECTRIC CONSTANT ϵ_r (4)
(1)				
Circular Plate Electrode	Plate Electrodes with Guard Ring 	$C_0 = \frac{\pi}{4} \epsilon_0 \frac{(d_1 + g)^2}{a} = 0.0696 \frac{(d_1 + g)^2}{a}$	$C_e = 0$	$\epsilon_r = \frac{C_x}{C_0}$
	Plate Electrodes without Guard Ring i) Electrode Diameter = Test Piece Diameter 	$C_0 = \frac{\pi}{4} \epsilon_0 \frac{d_1^2}{a} = 0.0696 \frac{d_1^2}{a}$	For electrode thickness $t \ll a$ (electrode very thin): $C_e = \pi d_1 (0.058 l_g - \frac{1.5}{a} + 0.0185)$ For electrode thickness $t < a$ (electrode thicker): $C_e = 0.0326 \pi d_1 (l_g \frac{8 \pi d_1}{a} + z - 1.305)$ $z = (1+x) l_g (1+x) - x l_g x$ $x = \frac{t}{a}$	$\epsilon_r = \frac{C_x - C_e}{C_0}$
	ii) Electrode Diameter < Test Piece Diameter 		When electrode thickness $t \ll a$, the dielectric constant of the test piece is roughly estimated (ϵ'_r). Then $C_e = \pi d_1 (0.058 l_g \frac{1.5}{a} + 0.0185 \epsilon'_r)$	
	iii) Electrode Diameter < Test Piece Diameter < Counter Electrode 		When electrode thickness $t \ll a$, the dielectric constant of the test piece is roughly estimated (ϵ'_r). Then $C_e = \pi d_1 (0.077 l_g \frac{3.8}{a} + 0.0405 \epsilon'_r)$	
Cylinder Electrode	Cylindrical Electrodes with Guard Ring 	$C_0 = \frac{0.2416 (l_1 + g)}{l_g (1 + 2a) \frac{d_1}{d_1}}$ When $a < d_1$, the rough formula is: $C_0 = 0.2782 (l_1 + g) (d_1 + a) \times \frac{1}{a} \left[1 - \frac{1}{2} \left(\frac{a}{d_1 + a} \right)^2 \right]$	$C_e = 0$	$\epsilon_r = \frac{C_x - C_e}{C_0}$
	Cylindrical Electrodes without Guard Ring 	$C_0 = \frac{0.2416 l_2}{l_g (1 + 2a) \frac{d_1}{d_1}}$ When $a < d_1$ the rough formula is: $C_0 = 0.2782 l_2 (d_1 + a) \times \frac{1}{a} \left[1 - \frac{1}{2} \left(\frac{a}{d_1 + a} \right)^2 \right]$	When $\frac{a}{a + d_1} < \frac{1}{10}$, the dielectric constant of the specimen is roughly estimated (ϵ'_r). Then $C_e = 2 \pi (d_1 + a) \times (0.058 l_g \frac{1.5}{a} + 0.185 \epsilon'_r)$ When $\frac{a}{a + d_1} < \frac{1}{6}$ and the test piece length $> l_2 + 10 a$, measure at two different test piece lengths and eliminate peripheral influence by subtraction of the results.	

b) Determination of the Stray Capacitance C_g

The capacitance of an electrode against earth is in first approximation (error limit about ± 25 percent):

$$C_g = 0.03 \frac{F}{\sqrt{h}} + 0.3 a \text{ pF}$$

where

F = Measurement surface in cm^2 ,
 h = Mean height in cm above the earthed ground surface, and
 a = Thickness of the test piece in cm.

As in the Original Standard, this Page is Intentionally Left Blank

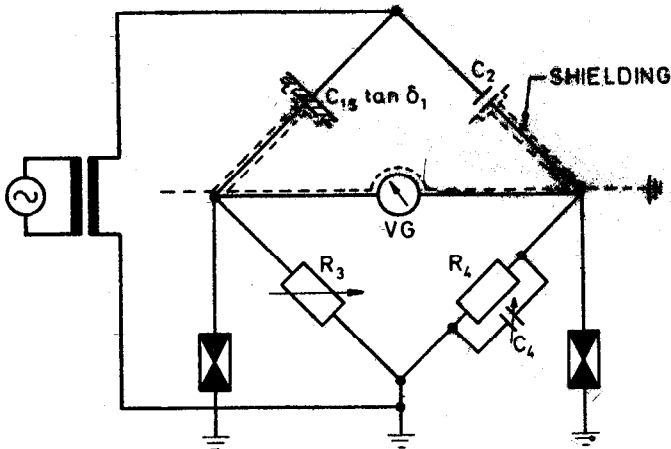


FIG. 11 HIGH VOLTAGE SCHERING BRIDGE

- b) *Measurement* — By gradually increasing the sensitivity of the vibration galvanometer that has been tuned to resonance, adjust first R_3 up to minimum deflection then C_4 , repeating the process alternately till there is no further reduction of the VG deflection. Check that with commuted VG the deflection does not alter. If there is a small alteration, again adjust to zero deflection and average the results. Larger deflections after commuting are reduced by removing the magnetic disturber. Disturbance is caused by all current carrying untwisted ac lines, transformers, etc. They should, therefore, be shielded.
- c) *Evaluation* — In the balanced state of the bridge

$$C_{1s} = C_2 \cdot \frac{R_4}{R_3} \quad \dots (1)$$

$$\tan \delta_1 = R_4 \cdot \omega \cdot C_4 + \tan \delta_2 \quad \dots (2)$$

when C_2 is subject to loss and has the loss angle δ_2 .

The potentiometer bridge according to Fig. 12 with the potentiometer wires (slide loops) a and b is more simple in input, as particularly for C_4 a solid capacitor may be chosen. Slide loops a and b are so calibrated that

$$C_{1s} = C_2 \cdot a \quad \dots (3)$$

When a is at the same time a factor that may be read off at the position of the loop contact.

$\tan \delta_1$ is read off directly from the position of the loop contact at b .

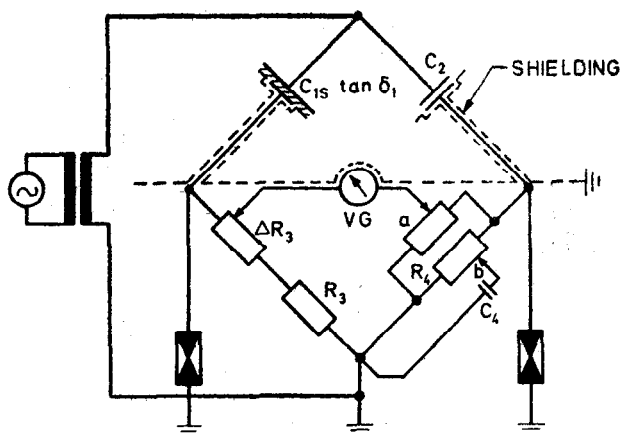


FIG. 12 SLIDE WIRE BRIDGE ILLUSTRATION OF THE PRINCIPLE

6.2.6 The dielectric constants and the loss tangent should be determined on at least 3 test pieces and rounded off to integer units.

The temperature coefficient for the dielectric constant should be given as a numerical value or, if in the temperature range under consideration, it is not approximately constant it is shown as a curve. The temperature coefficient of the dielectric loss tangent shall always be given as a curve.

6.3 Specific Resistance (Effective Resistance) in Relation to the Temperature

6.3.1 The resistance is the ratio of the voltage at a test piece to the actual current flowing through the test piece.

6.3.1.1 The specific resistance (ϵ_D) is the resistance of a cube of 1 cm side in Ω cm.

6.3.1.2 Since at room temperature the resistance is very low and, therefore, for direct voltage may be measured only with sensitive instruments and that too only roughly. The specific resistance for the temperature range from 20 to 200°C should be calculated from the dielectric constant and the dielectric loss angle values determined according to 6.2. The simplified assumption that the test piece affected by the dielectric loss may be replaced by a loss-free capacitor with parallel connected resistance is applied.

6.3.1.3 The specific resistance is then calculated according to the following formula:

$$\epsilon_D = \frac{1.8}{f \cdot \epsilon_r \cdot \tan \delta} \times 10^{12}$$

where

- ϵ_D = specific resistance in Ω cm,
- f = frequency in Hz,
- ϵ_r = relative dielectric constant, and
- $\tan \delta$ = dissipation factor.

6.3.2 Measurements at temperatures 300°C and above are provided only for insulators. The resistance with alternating voltage at 50 Hz is determined from the current and the voltage, using an ammeter of sufficient sensitivity to measure the current in the insulation and a voltmeter.

6.3.2.1 When calculating the specific resistance from the measured impedance, the reactive current taken by the test piece may be neglected since at high temperature it is very small compared to the active current. The impedance, therefore, corresponds in rough approximation to the ac resistance.

6.3.3 The test pieces are flat round plates of a diameter about 40 mm and thickness about 3 mm. The material of the electrode is silver or platinum which is burnt on in a permanent fashion to the surface of the test piece. Silver electrodes are suitable only for measuring ranges up to 600°C.

6.3.4 An electric stove is used for heating the test piece. The stove space should be large enough to assure a uniform temperature of the test piece. The heating and cooling rates should be so adjustable that the stove temperature increases or decreases by 200 to 300°C per hour. The temperature of the test piece is measured with a thermoelement whose hot junction is positioned in the immediate neighbourhood of the test piece. The measuring voltage is applied to the electrodes through platinum wires or strips which are pressed on to the electrodes with a force of at least 0.5 N. The measurement is taken both during the heating as well as during the cooling. The calculation is based on the mean value of the resistance measurements during heating and cooling.

6.3.5 The resistance should be determined on at least two test pieces and indicated for 20, 200, 400, 600 and, if necessary for 800 and 1 000°C.

6.4 Surface Resistivity

6.4.1 The surface resistivity is the quotient of the applied voltage and the current flowing over the surface per unit width of the surface. It gives an indication of the condition of insulation at the surface of an insulating material which is liable to be altered by external influences like moisture, impurities, chemicals.

6.4.1.1 Since the measurement of the surface resistivity comprises not only the resistance at the surface of the insulating material but partly also that of the insulator, the specific surface resistivity has to be calculated separately.

6.4.2 The test pieces may be flat plates, bars or tubes whose surface should not be altered, damaged or machined.

6.4.3 The electrodes are two graphite or precious metal strips of 100 mm length with a spacing of 10 ± 0.1 mm between them.

6.4.4 The surface current is measured with a galvanometer one minute after applying a dc voltage of 1 000 V.

6.4.4.1 The surface resistivity R_0 is given by Ohm's law.

6.4.5 The measurements shall preferably be carried out in an air controlled chamber immediately after the preliminary treatment since after the removal of the test piece from this chamber the moisture at the surface and hence the surface resistivity may also alter considerably.

6.4.6 The surface resistivity R_0 is determined on three test pieces and expressed in ohms.

6.5 Arc Resistance

6.5.1 The test is for determining to what extent the insulating material participates in the carrying of the current or is materially altered either permanently or temporarily under the action of the arc.

6.5.2 Testing Apparatus

- a) *Electrodes* — Two pure carbon rods of 8 mm diameter.
- b) *Arrangement for holding the electrodes* at an angle of slightly more than 90° with respect to each other in a plane at 60° to the horizontal, on the horizontal test piece, and moving the electrodes away from each other at a speed of 1 mm/s.
- c) dc voltage source of 220 V.
- d) Resistance connected in series of 10 ohms.

6.5.3 Taking, Preparation and Shape of the Test Piece — These shall be according to the relevant standards on the insulating material. The test piece is a plate of 120×120 mm.

6.5.4 Test Procedure

6.5.4.1 The electrodes are placed on the horizontal test plate with an arrangement according to 6.5.2(b). A resistance of 20 ohms is connected in series to the electrodes and a dc voltage of 220 V is applied. After the formation of the arc between the electrodes, these are withdrawn away from each other with a maximum speed of 1 mm/s and the grade of arcing resistance is fixed according to 6.5.4.2.

During the action of the arc the conducting of current is checked by inspection.

After cooling, the electrodes are again placed on the trace left by the arc to check whether a conducting bridge remains in the insulating material.

The arrangement of the electrodes should be such that the gases rising

from the arc may freely escape upward. When the current is conducted by the insulating material, the arc that generally burns upward disappears in the insulator surface that glows and has become partly or fully conducting.

3) : **6.5.4.2** There are six grades of arc resistance as follows (see also Table 3) :

Grade L_1 — Under the arc which may be struck to over 20 mm length, a conducting bridge is formed in the insulating material which remains conducting even after cooling.

Grade L_2 — Under the arc which in part cannot be drawn over 20 mm length, a partly conducting bridge is formed in the insulating material which loses its conducting property after cooling. Because of the heat, the insulating material cracks.

Grade L_3 — Under the arc which may be drawn to over 20 mm length, a partly conducting bridge is formed in the insulating material which loses its conducting property after cooling.

Grade L_4 — The arc cannot be struck to its normal length of 20 mm. Under the arc no conducting bridge is formed. Because of the heat, the insulating material splits.

Grade L_5 — The arc may be struck further than 20 mm, but it does not form any connected bridge in the insulating material. There are also no occurrences as mentioned for Grades L_2 and L_4 (cracking or splitting of the insulating material).

Grade L_6 — The arc may be struck above its normal length of about 20 mm, and no continuous conducting bridge is formed in the insulating material. Also there are no occurrences as for Grades L_2 and L_4 (cracking or splitting of the insulating material).

TABLE 3 GRADES OF ARCING STRENGTH (OR RESISTANCE)

[Clauses 6.5.4.2 and 7.1(c)]

GRADE	DETERMINATION			
	Arc May be Struck Up to mm	Conducting Bridge in Insulating Material		Behaviour of the Insulating Material
		Under arc	After cooling	
(1)	(2)	(3)	(4)	(5)
L_1	>20	Yes	Yes	Carbonized or burnt
L_2	Partly <20	Partly yes	No	Split
L_3	>20	Partly yes	No	—
L_4	<20	No	No	Melted and vaporized
L_5	>20	No	No	—
L_6	<20	No	No	—

6.6 Maximum Thermal Shock Temperature

6.6.1 Test Piece — The test piece is in the form of a solid cylinder 20 ± 1 mm long and is prepared by the same process as for production articles.

6.6.2 Method of Test — Heat the test pieces to the first test temperature and maintain at that temperature for at least 30 minutes. Arrange the furnace so that the test pieces may fall freely into a bath of cold running water at 10 to 20°C. Quench the test pieces in this manner for at least five minutes and then examine for cracks with the aid of a dye. If there are no visible signs of failures, replace the test pieces in the furnace and repeat the cycle at a temperature 10°C higher. Repeat the process and state the lowest temperature at which two or more failures occur as the maximum thermal shock temperature. Commence the test at the temperature which all test pieces will withstand satisfactorily. When the maximum thermal shock temperature exceeds 200°C, make the temperature increments 25°C.

6.6.2.1 The results shall be stated as maximum thermal shock temperature in °C and the limits shall be agreed between the purchaser and the manufacturer.

6.6.3 Detection of Cracks By Dye Method — Pieces of insulating material shall be immersed in one percent alcoholic solution of fuchsin (1 g fuchsin in 100 g of methylated spirit) under a pressure of not less than 15 MN/m² for a period such that the product of the test duration in hours and the pressure in MN/m² is not less than 180.

The pieces shall then be removed from the solution, washed, dried and broken. Examination with naked eye of the freshly broken surface shall not reveal any dye penetration. Penetration into small cracks formed during the initial breaking shall be neglected.

7. TEST REPORT

7.1 The test report should contain reference to this standard and the following information :

- a) Type, designation and shape in which the insulating material has been supplied;
- b) Preparation, form, dimensions and date of preparation of the test piece;
- c) Arcing resistance and grade according to Table 3; and
- d) Date of testing.

APPENDIX A*(Clause 3.9.1)***MODIFIED MOHS SCALE****A-1. HARDNESS NUMBER**

A-1.1 The hardness number of various minerals according to the modified Mohs scale is given below:

<i>Original Mohs Scale</i>		<i>Modified Mohs Scales</i>	
<i>Hardness Number</i>	<i>Minerals</i>	<i>Hardness Number</i>	<i>Mineral</i>
1	Talc	1	Talc
2	Gypsum	2	Gypsum
3	Calcite	3	Calcite
4	Fluorite	4	Fluorite
5	Apatite	5	Apatite
6	Orthoclase	6	Orthoclase
7	Quartz	7	Vitreous silica
8	Tapus	8	Quartz or stellite
9	Corundum	9	Tapus
10	Diamond	10	Garnet
		11	Fused zirconia
		12	Fused alumina
		13	Silicon carbide
		14	Boron carbide
		15	Diamond

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones: 323 0131, 323 3375, 323 9402

Fax : 91 11 3234062, 91 11 3239399, 91 11 3239382

Telegrams : Manaksanstha

(Common to all Offices)

Telephone

Central Laboratory:

Plot No. 20/9, Site IV, Sahibabad Industrial Area, Sahibabad 201010 8-77 00 32

Regional Offices:

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002 323 76 17

*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054 337 86 62

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022 60 38 43

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113 235 23 15

†Western : Manakalaya, E9, Behind Marol Telephone Exchange, Andheri (East), MUMBAI 400093 832 92 95

Branch Offices::

'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001 550 13 48

‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058 839 49 55

Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003 55 40 21

Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001 40 36 27

Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037 21 01 41

Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001 8-28 88 01

Savitri Complex, 116 G.T. Road, GHAZIABAD 201001 8-71 19 96

53/5 Ward No.29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003 54 11 37

5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001 20 10 83

E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001 37 29 25

117/418 B, Sarvodaya Nagar, KANPUR 208005 21 68 76

Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001 23 89 23

NIT Building, Second Floor, Gokulpat Market, NAGPUR 440010 52 51 71

Patliputra Industrial Estate, PATNA 800013 26 23 05

Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005 32 36 35

T.C. No. 14/1421, University P. O. Palayam, THIRUVANANTHAPURAM 695034 6 21 17

*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072 27 10 85

†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007 309 65 28

‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002 222 39 71

Printed at Printograph, New Delhi (INDIA)